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Colonisation and Steadyness of Carabid Beetles in Orchards

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Abstract. From April 1995 to November 1997 investigations were carried out in the nature reserve "Limburg" (48.36 N/9.23E): data were collected on the type and frequency of grassland use and data on the carabid fauna. 17 sample plots were selected. Part of the plots had 25 years of unchanged management regimes: three-cutting meadows (3), two-cutting meadows (3), mulched meadows (4), abandoned meadows (3), a horse pasture, a sheep pasture with rotational grazing, a continuously grazed sheep pasture, and a sheep pasture abandoned in 1994.

5229 beetles representing 68 carabid species were caught in pitfall traps during the three years of investigation on the 17 study plots (Tab. 2). On nearly all studied areas/plots changed the relative frequency of dominant species. 3-cutting meadows frequently show a one-sided activity dominance structure. Within the yearly spectrum of activity dominance on all areas it is obvious that species occured and are leaving continously.

Rare species in the area (steadyness group I: present on 1–3 plots) reached percentages between 10 % and 42 %, the corresponding values for steadyness group II (species present on 4–6 plots) are 0 % up to 67 % und steadyness group III (present on 7–10 plots) 20 up to 64 % (Fig. 2, Tab. 3). The management of the grass vegetation in orchards and the influence on the carabid community is briefly discussed.

Keywords. Ground beetle, grassland management, species colonisation, species steadyness.

1. INTRODUCTION

Vegetation and fauna of extensively managed orchards are mainly determined by the site and its maintenance, the type of grassland management and its land use intensity (Deuschle et al. 2002, Glück et al. 2004).

Until now animal communities of extensively managed orchards have not been analysed based on the direct comparison of different forms of grassland management There are few investigations dealing with the influence of management systems on arthropod communities in extensively managed grassland, whereas the effects of grazing have been documented more frequently (Hanssen & Hingst 1995, Maelfait et al. 1988, Rushton et al. 1989, Schnitter 1994, Deuschle & Glück 2001, Glück & Deuschle 2003).

Carabids showed a higher activity on cut and mulched meadows than on plots in state of succession during abandonment trials (Southwood & Van Emden 1967). But the abandonment of two meadows, one fertilised and the other one unfertilised, lead to an increase of the activity density during the course of succession (Schnitter 1994). Low food resources – determined by differences in a decrease of the population – caused a lower activity density in woodlands (Guillemain et al. 1997).

Beside describing represent field studies in the last years was tried to explain and scale the differential character of carabid communities. Abiotic and management specific characters and gradients have been worked out. (Baguette 1993, Bauer 1989, Butterfield & Coulson 1983, Dennis *et al.* 1997, Dufrene & Legendre 1997, Eyre *et al.* 1990, Huhta 1979, Luff et al. 1992, Luff 1996, Mc Ferran et al. 1994, Morris & Rispin 1987, Preiszner 1996, Rode 1993, Vowinkel 1996, Glück & Deuschle 2003).

The aim of this paper is to ask wether carabids colonize relatively homogenous orchards constantly in nearly the same species and individual densities or in a more stochastic manner, or is there a concentration on some plots/ habitats of specieal species. The species therefore were divided into three classes of steadyness (see 2.2). The constancy in time of the composition of carabid community is inspected and how it is linked up management specific at the background of different management regimes, different area, the distribution with altitude and the shading of the plots. Analysis of similarity of the carabid communities and the activity dominances on the plots show a pattern in time and space of the species compsition and dominance idendities of different management regimes.

2. METHODS

2.1. Census and registration of land use

From the beginning of April until the middle of October 1997 the following parameters were recorded weekly or every two weeks in the study area orchards in the nature reserve "Limburg" (48.38N/9.23E), south west Germany: type of use, time of mowing, "mowing device", "whereabouts" of mowed grass, and number of grazing animals. The amount of ground shaded by trees under perpendicular solar radiation was estimated and assigned to six categories.

All areas, which are mowed completely on a regular basis every year and where the cut grass is removed, will be called "typical meadows". On "mulched meadows" the cut grass remains regardless of the mowing device and mowing frequency. "Continuous grazing" defines the management type of pastures, where the grazing animals can be found permanently on the same area, while "rotational grazing" is the type, where a particular area is being grazed for a period of only a few days, but several times a year. Combinations of the three types of management can also be found in the extensively managed orchards of the nature reserve area.

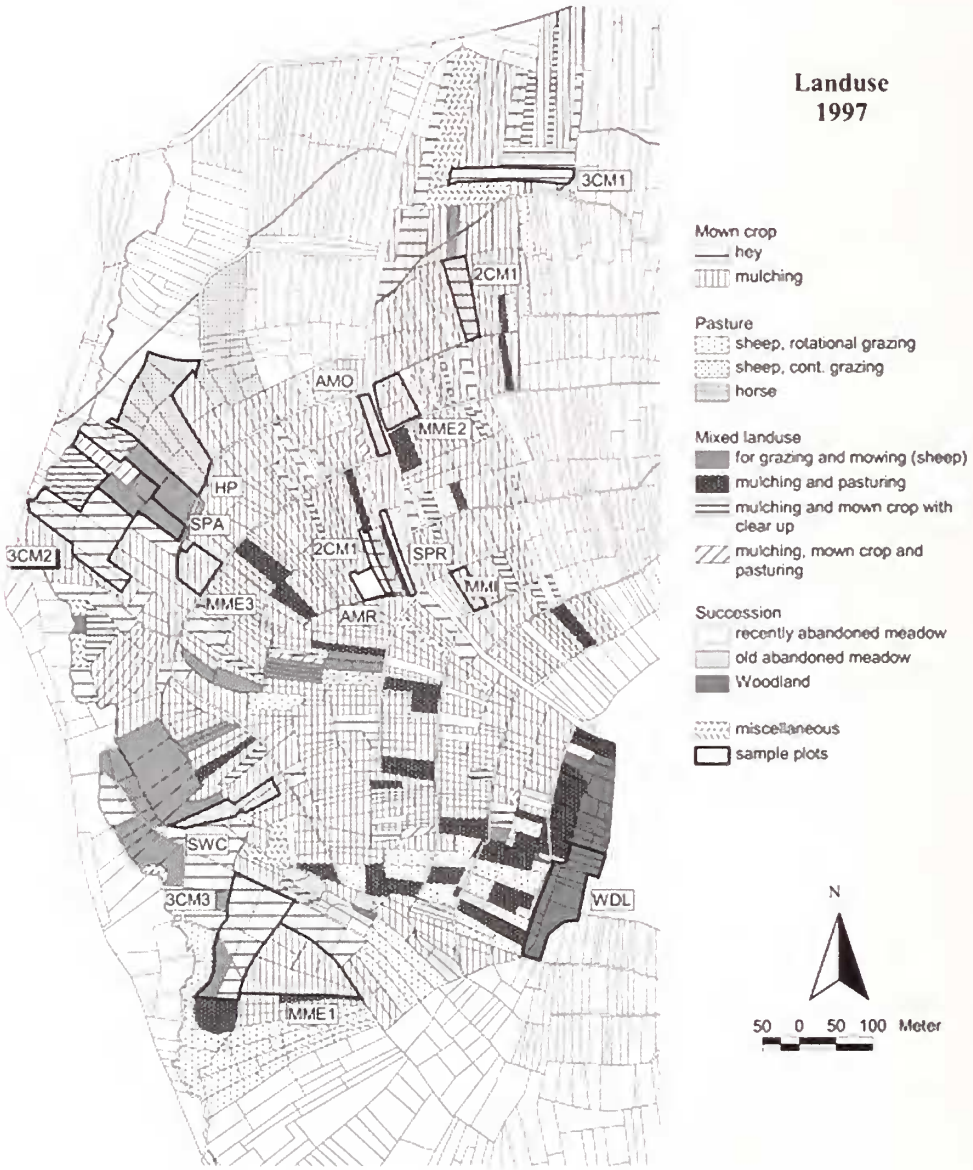

Fig. 1. Land use intensity of grassland in the study area during the vegetation period of 1997 and the sample plots.

2.2. Selection of sample plots and Population census

In 1995 the selection of sample plots took into consideration areas which had been under the same management system for more than 25 years (see Fig.1, Tab. 1).

Six pitfall traps were placed in a single line 10 m apart as a transect through the centre of each sampling plot. Ethylene glycol (50 %) was used as preservative solution, with detergent added to reduce surface tension. A cover made of Perspex (120 by 120 mm) was installed 30–50 mm above ground level. In 1995 (5. April to 1. November) traps were controlled and emptied regularly weekly. In 1996 (5. May to 4. November) and 1997 (8. April to 4. November) the control interval was two weeks (Deuschle & Glück 2001).

The division in classes of steadyness helps to classify the rareness in the study area, independent from their plot specific frequency, where ever this scarcity is only valuable for the individual study plots. The species were divided into three classes of steadyness: steadyness I are all species occuring on 1–3 plots, steadyness II species occuring on 4–6 plots, steadyness III species occuring on 7–9 plots.

2.3. Analysis of data and statistical methods

All registered data concerning management practices, vegetation, soil condition, and carabid population were integrated into a database. After examining the necessary conditions the following statistical tests were applied: U-test by Mann & Whitney (MWU-test), and X^2-test. The rank correlation was calculated according to Spearman and the coefficients were tested on their significance.

3. RESULTS

3.1. Acitivity dominance

The activity density of carabids on the various plots is quite different (Tab 2). The yearly activity density on the three fold mowed meadow (3CM1) showed differences in the distribution of the second up to the fifth dominant species. The percentages of these species (*Amara aenea, Pseudoophonus rufipes, and Nebria brevicollis*) decrease continually within the three year study. In 1995 *P. rufipes* and *N. brevicollis* were the third respective fifth dominant species an 1997 both were totally absent. In contrast to this the percentages of *Clivina fossor, Poecilus cupreus*, and *Carabus ullrichi* steadily increase throughput the three year period. Only *Anisodactylus binotatus* in all three years remained as the cominant species despite of its changing perdentages in the area. Six species occured 1995 in a low density, they were absent in 1996 and occured again in low density 1997. In 1996 and 1997 seven species are registered which were not collected in 1995 in the pitfall traps, two of the species were captured only in 1996, and three species out of them in 1997. On the 2-cutting meadow (2CM1) the dominant species changed during the three years of investigation: *Harpalus latus,* the activity of which decreased countinously is removed by *C. ullrichi* the percentage of which increased. The next following species hold nearly the same dominance ranks with the years. Three species are only in 1995 and 1997, seven species only in 1995 registered. Eight more species are only present in 1996 and 1997, two out of them only in 1997.

On the horse pasture (HP) all years the dominance of species changes from *C. fossor* to *Pterostichus vernalis* on to *Pterostichus melanarius*, the percentage of the latter increased from 1% in 1995 to 8.5% up to 29.1% in 1997. The percentages of the other dominant species decrease with the years. *A. plebeja* is registered only in 1995; *Amara familiaris* and *C. ullrichi* restricted their occurance in 1995 and 1997 also on this plot. In contrast in 1996 new species occured in the community, six more species in 1997 by most of them only one individual was collected.

On the anbandoned sheep pasture (SPA) *P. melanarius* remains as the most dominant speacies and reached eudominant status, with 39,4 % in 1995 and 58,4 % in 1997. *N. brevicollis* disappeared on this plot in 1997. This species ranked in 1995 still on the second dominance position. Three species were registered exclusive on this plot in 1995, five only in 1996 and six species only in 1997.

On the sheep pasture rotational grazing (SPR) *C. ullrichi* was the most dominant species througout the three years. *Pterostichus ovoideus* strongly increased and was collected in the same frequency as *C. ullrichi.* On this plot four species occured only in 1995 or 1996, five more occured only in 1997.

On the mulched meadow (MMI) *Leistus ferrugineus* removed the so far most frequent *C. fossor* 1997. *L. ferrugineus* occured the first time in this community, reached a percentage of 6,1 % and is ordered in status to the subdominant carabids. The percentages of species belonging to the dominant ones in 1995 changed strongly and are displaced by the so far subdominant species as *C. ullrichi.* Seven species are trapped only in 1995, ten more species in 1996 and 1997 four out of these only in one of both years.

The dominance spectrum is wellbalanced on the mulched meadow (MME2). *H. latus* reaches all the years' eudominant status. Three species are registered only in 1995, two more in 1996 and no more in 1997.

Table 1. Morphology and land use of sampled plots.

Plot	Land use	Type of land use	Area (Ar)	Circumference (m)	Altitude (mNN)	Shading (%)	Sampling period
3CM2	3-cutting meadow	Meadow	26	209	405	20	`97
3CM3	3-cutting meadow	Meadow	51	287	425	20	`97
3CM1	3-cutting meadow	Meadow	16	204	392	20	´95,´96,`97
2CM3	2-cutting meadow	Meadow	40	446	415	80	`97
2CM1	2-cutting meadow	Meadow	10	218	445	60	´95,´96,`97
2CM2	2-cutting meadow	Meadow	15	250	410	60	`97
SPA	abandoned sheep pasture (continuous grazing), see text	Pasture	34	234	405	60	´95,´96,`97
SPC	Sheep pasture (continuous grazing)	Pasture	15	213	415	80	`97
HP	Horse pasture	Pasture	124	580	400	20	´95,´96,`97
SPR	Sheep pasture (rotational grazing)	Pasture	11	259	445	20	´95,´96,`97
MM1	Mulched meadow (4 - 6 cuttings)	Mulched meadow	12	162	455	20	´95,´96,`97
MME1	Mulched meadow (3 cuttings)	Mulched meadow	47	380	440	100	`97
MME2	Mulched meadow (2 – 3 cuttings)	Mulched meadow	29	217	420	60	´95,´96,`97
MME3	Mulched meadow with 1 cutting	Mulched meadow	25	206	517	80	`97
AMR	Recently abandoned meadow (4 years)	Succession	13	153	445	0	´95,´96,`97
AMO	Old abandoned meadow (10 years)	Succession	13	202	420	100	´95,´96,`97
WDL	Woodland	Succession	13	222	520	100	`97

On the recently abandoned meadow (AMR) *H. latus* displaced 1996 the so far most frequent *A. binotatus,* the latter belonged in 1996 and 1997 just to the group of subdominant species.

The percentages the persuiting dominant species on the plot *P. ovoideus*, *C. fossor* and *Bembidion obtusum* changed strongly during the years. Four species are registered only 1995, six more only in 1996 and 1997.

In the dominance spectrum of the old abandoned meadow (AMO) set apart from the percentages of the most frequent and dominant species from year to year considerably and lead to a yearly change in the ranking of the community, during the course1996 and 1997 only few species added new into the community.

Spectrum and the ranking of dominant and subdominant of species change strongly within the study plots and years. Regarding comparative management forms there are great differences regarding the main species in the spectrum (Tab. 2).

The percentage of the most frequent species compared to the number of all species together did not show any connection with the number of species or individuals nor the management of the plots. The maximal and minimal values are given on three year investigated plots on the abandoned sheep pasture (SPA, 58,4 %) in 1997 and on the horse pasture (HP, 13,9 %) 1996).

On the one year investigated plots owns the 3-cutting meadow (3CM3) with 16,4 % the lowest value , the like-

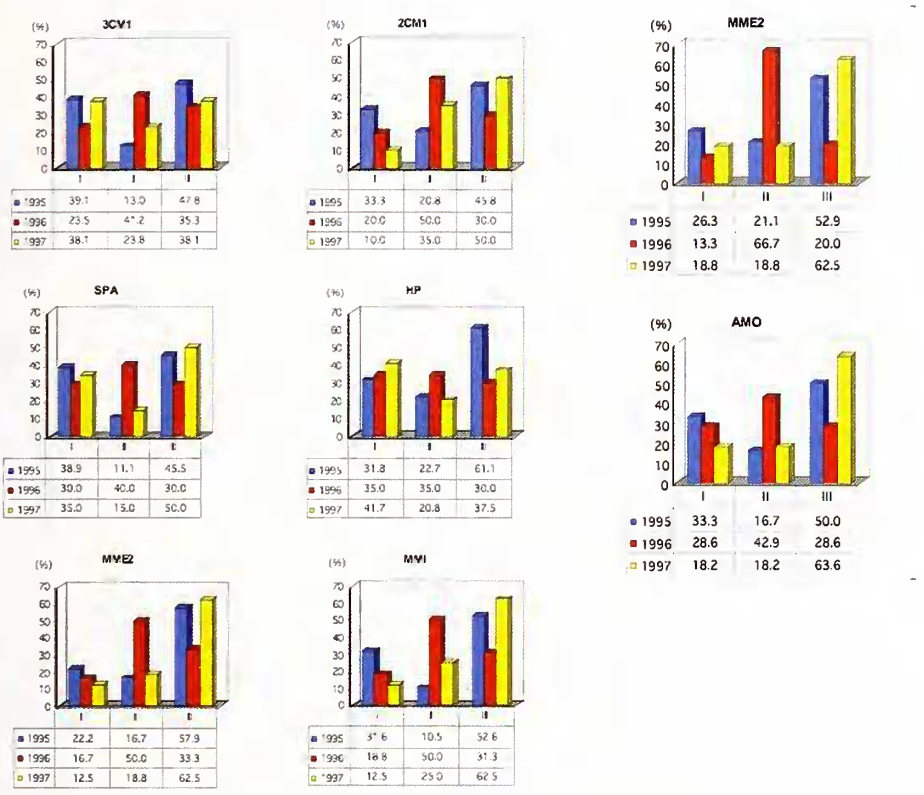

Fig. 2. Steadyness of carabid species from 1995–1997 on plots of different management 3CM1, 2CM1, SPA, HP, MME2 and MMI (left) / MME2, AMR and AMO (right) (species percentages).

wise 3-cutting meadow (3CM3) with 49,4 the highest value. Eleven different species built up the most frequent carabid on the three year investigated plots; *H. latus* was for seven times the most frequent on the nine investigated plots. Only on the areas 3CM1, MME2 and SPA in all three years the same species reach the highest frequency (*A. binotatus, H. latus* and *C. ullrichi*). From the other species are *C. ullrichi, C. fossor, A. binotatus, P. vernalis* und *P. ovoideus* high steady and occur on nearly all other plots. *P. melanarius* und *A. parallelepipedus* are registered only on a few investigated plots. The arrangement of the most frequent and second most frequent species does not show any affinity to compatible or to near by standing management forms.

3.2. Steadyness of species on the plots

The determined steadyness allows on the three year studied areas/plots a differentiation between three groups. The first group consists of species which colonize regularily two-third of the study plots (Steadyness III, Fig. 2). This group comprises 1995: 11 (24 %) of altogether 46 species, 1996: 6 (15 %) from 39 species and 1997: 10 from 38 (26 %) species. The second group (steadyness II) comprises 1995: 8 (17 %), 1996: 14 (36 %) und 1997: 7 (18 %) of the species. The third group comprises the large part of all detectable species (Steadyness I). 27 (59 %) of the species 1995 contained in the pitfall traps were only present on one to three study areas/plots. In 1996 19 (49 %) species belonged to this group, 1997: 21 (55 %). With this the percentages of the classes of steadyness in 1995 und 1997 are comparable. 1996 evidence of some rare species in the study area/plots are absent (probably dependent on the low activity). In 1995 more frequent species are detected on less study plots, so in 1996 the steadyness class II was comparatively high occupied (Fig. 2).

The highest proportions of steadyness I were registered on the 3-cutting meadow (3CM1) and on the abandoned sheep pasture (SPA) (39 %), the lowest percentages of this class were in the carabid community on the plot 2CM1 (1997: 10 %, Fig. 2). The percentages on the plots are between 7 % (MME2) and 23 % (2CM2), beside the horse pasture (HP) the values are in 1996 negligible lower compared to 1995 oder 1997.

Some of this rare species in the study area are able to establish in seperate years or continously on distinct plots larger populations. To this species belong *Abax parallelepipedus*, *Amara aenea*, *Bembidion properans* or *Pterostichus melanarius*.

Table 2. Density of species, activity abundance, dominance index, area specific proportions of main and accessory species and the most frequent species each in the perennial sample plots (1995–1997).

Area:		3CM1	2CM1	SPA	HP	SPR	MMI	MME2	AMR	AMO
Number of species	1995	23	24	18	22	18	19	19	17	12
	1996	17	20	20	20	18	16	15	17	7
	1997	21	20	20	24	16	16	16	16	11
Number of individuals:	1995	226	144	226	200	76	95	86	84	81
	1996	64	58	81	130	69	49	41	82	56
	1997	125	75	267	234	87	106	113	60	58
Percentage of Main species: (%)	1995	26,1	31,8	27,8	36,4	55,6	42,1	52,6	41,2	66,7
	1996	58,8	65,0	35,0	45,0	50,0	56,3	66,7	41,2	85,7
	1997	42,9	50,0	25,0	37,5	62,5	62,5	31,3	50,0	72,7
Percentage of Accessory sp.: (%)	1995	73,9	68,2	72,2	63,6	44,4	57,9	47,4	58,8	33,3
	1996	41,2	35,0	65,0	55,0	50,0	43,8	33,3	58,3	14,3
	1997	57,1	50	75,0	62,5	37,5	37,5	68,8	50,0	27,3
dominance index (%):	1995	25,5	31,3	39,4	18,0	31,6	33,7	29,1	16,7	37
	1996	15,6	22,4	25,9	13,9	18,8	18,4	29,3	24,4	48,2
	1997	31,2	21,3	58,4	29,1	18,4	19,8	28,3	30,0	24,1
Most frequent species:	1995	*Anisod. binotatus*	*Harpalus latus*	*Pt. melanarius*	*Clivina fossor*	*Carabus ullrichi*	*Clivina fossor*	*Harpalus latus*	*Anisod. binotat.*	*A.parallelepipedus*
	1996	*Anisod. binotatus*	*Harpalus latus*	*Pt. melanarius*	*Pt. vernalis*	*Carabus ullrichi*	*Clivina fossor*	*Harpalus latus*	*Harpalus. latus*	*Molops elatus*
	1997	*Anisod. binotatus*	*Carabus ullrichi*	*Pt. melanarius*	*Pt. melanarius*	*C. ullrichi/ Pt. ovoideus*	*L. ferrugineus*	*Harpalus latus*	*Harpalus. latus*	*A.parallelus /Harpalus latus*

The area specific percentages in class II stagger between 0 % (AMR 1997) und 50 % (SPR, MMI 1996). The scattering on the plots within the 3 year study is essentially higher in this class of steadyness I, the values are beween 14 % (HP) und 47 % (AMR).

Species of steadyness III colonized all study plots/areas. The highest percentages in this class are on AMO (64 %) und MME2 (63 %) in1997. On the same areas are the lowest percentages in 1996 (29 % bzw. 20 %). The area specific percentages of the community stagger considerably (13–43 %).

The unequivocal distribution of the steadynes shows clear, that within the relatively homogeous and enclosed orchards in the study area exist numerous small-patterned differences which can lead to inhomogenous distributions on neughbouring areas. A smaller part of species colonizes the orchards in changing frequencies nearly overall. The majority of species concentrate abviously only on small-patterned and local distribution centres, Their discontinually and recedental occurance in other areas allows the interpretation that ther behaviour is a navigational exploration.

1996 and 1997 the percentage of rare species (steadyness I) increased with increasing area of the plots, 1997 the correlation was statistically significant (Tab. 3). In the three years of investigation the percentage descreased with increasing altitude, the correlation in 1997 was statistically significant.

The steadyness seems not to be correlated with the parameters of the plots like management, circumference and shading; the correlation analysis did not show any tendencies. Only 1997 the percentage of frequent species (steadyness III) increased with decreasing management intensitymit, 1996 the percentage decreased statistically signif-

Table 3. Rank correlation coefficient of species percentages of different steadyness classes of the carabid community with area parameters (n = 9; level of significance: * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$).

	Species percentages	Management	Area	circumference	altitude	shading
1995	SC I	-0.56	0.28	-0.01	-0.59	0.33
	SC II	0.12	0.19	0.36	-0.18	0.03
	SC III	0.38	0.13	0.27	0.11	-0.34
1996	SC I	-0.35	0.52	0.32	-0.60	0.22
	SC II	0.31	-0.63	-0.27	0.70*	0.09
	SC III	-0.28	-0.32	-0.26	0.13	-0.84**
1997	SC I	-0.11	0.81**	0.08	-0.76*	-0.37
	SC II	-0.55	-0.34	0.16	0.12	0.01
	SC III	0.77*	-0.40	-0.43	0.57	0.34

icant with increasing shading. So that seems between the comparatively rich species mowing meadows and pastures and the scarce species areas like abandoned and mulching meadows are no differences in the percentages of rarely or frequent species in the sudy area (Tab. 3).

In contrast the percentages of rare species (steadyness I) increase with increasing area 1996 and 1997, 1997 the correlation was statistically significant. In all three years the percentage of these species decreased with increasing altitude of the study plots.

4. DISCUSSION

Three cutting meadows are colonized by numerous species, which occur either in a high population density and/or are not present on other areas. The typical speceis on three cutting meadows are predominantly spreeding and euritopic forms, which colonize a broad spectrum of different habitats. Some of this species, as *P. melanarius* or *C. fossor* indicate with high population densities intensive management forms (DESENDER *et al.* 1994, TIETZE 1985, 1987).

The species colonizing 3-cutting meadows belong mostly to steadyness III or I, but seldom to II. They are therefore either high frequent or very rare. In four of these species the individual density was significantly higher than on other study areas, on which they occured regularily in scarce populations (Tab. 2). These species belong mostly to steadyness III (*A. binotatus*, *P. cupreus*, *C. fossor*, exception: *Pt. melanarius*). *A. binotatus, P. cupreus* and *C. fossor* colonized all 3-cutting meadows continously and therefore in time and space on all areas of this management form present. All four species are capable to fly, two species are macropteric and two are alae dimorphic and therefore comparable mobil. However from *P. melanarius* and *C. fossor* no completely macropteric individuals were registered. Especially *P. melanarius* colonized the area 3CM2 and 3CM3 as well as the neighboured pastures in high population densities but was absent on 3CM1 (DESENDER *et al.* 1994). Obviously in its spreading pattern seems to be content an area dependent gradient, which had not been jet registered: in the sout-western part of the study area the species occured 1997 on nearly all studied plots therby also on pessimissm areas (MME3). In the north-eastern part of the area there are only some lonely individuals captured (1996: SPR, 1997: AMR) and in our opinion optimal areas (3CM1) have not been colonized. Large 3-cutting meadows and pastures are common in the south-eastern part of the study area, wheras they are on the remaining area more rare and smaller and mostly surrounded by mulching meadows. (Fig.1). The unability to fly and therefore beeing scarcely mobile in the investigated populations seems potentially more favorable colonizing, but prevents colonizing of secluded mowing meadows in other parts of the study area. Therefore the species overall distribution is not only based on suitable management forms or habitats but also on the attainment of exploring individuals of local populations, which depends on the species immanent mobility. With more typical species of 3-cutting meadows the density of individuals are clear lower, they colonize the plots with other management forms essentially more rare and fall mostly in steadyness class I. (*Amara aenea, Bembidion properans, Agonum mülleri, Poecilus versicolor; Carabus granulatus, Diachromus germanus, Amara montivaga).* Except *C. granulatus* (brachypteric), all individuals of the species are macropteric. They are therfore capable to fly and more mobil in contrast to the differential species of stedyness group III. In contrast to the differentiating species from steadyness group I on the studied 3-cutting meadows they are less continously present in time and space. This dis-

continous presence and the lower population density indicates a lower plasticity and a higher risk of extinction in local populations of this species, whereas eurytopic species with high plasticity even are able to colonize pessimal areas. For the latter therefore seems the ability to fly of reduced importance.

Some of the differential species on 3-cutting meadows (especially of steadyness group III) colonize pastures more frequently. These are *P. melanarius* and *P. vernalis* which colonize both management forms in higher populations densities than 2-cutting meadows, mulching or abandoned meadows. They mark the similarity of the carbid community of both management forms which obviously represent comparable living conditions. Species colonizing only pastures in high densely populations were only present by *Pt. macer* und *P. rufipes*. Their rarely population densities did not allow to mark off statistically signifcance to other management forms. (Fig. 2).

N. brevicollis and *C. ullrichi* have been trapped significantly more frequent on 2-cutting meadows compared to other management forms. Both species are counted to the more frequent ones (steadyness II / steadyness III) and colonize all other management forms at least in low densities (Fig. 2). But both species dave been very frequent on the area 2CM3 out of the direct Limburg area, and hint the first time an influence independent from the management form on the composition of specific carbid communities in orchards. The eurytopic *N. brevicollis* is a typical species of the woodland edge (THIELE 1964). Their densely population on 2-cutting meadows and scarce activity on abandoned areas is different from this findings, but a overall high presence on the study plots confirms the morphological relationship from orchards and thin woodlands. Both habitats offer obviously for *N. brevicollis* comparable living conditions (see GRUSCHWITZ 1983). After the scarce specifications, the rarely found species *C. ullrichi* (RL 3) inhabits a broad spectrum of various habitats with ist centre of distribution in Southern Europe. The statements are from loamy fields, meadows, and rural areas up to thin woodlands (HÜRKA 1996).This plasticity seems to correspond to the high steady presence on all studied plots.

Leistus ferrugineus, the only species with its centre of distribution in mulching meadows increased rapidly over the three year study (1995: steadyness I, 1996: II, 1997: III). In contrast euritopic species of abandoned meadows (*Carabus auratus, Abax parallelus, Abax parallelepipedus*) are more often present on meadows and pastures. *A. parallelus* (1995 – 1997: steadyness II) is more common than *A. parallelepipedus* (1995, 1997: steadyness I, 1996: II) and reaches moreover a higher population density on mulching meadows. *A. parallelus* therefore is the species with higher plasticity and a lower bonding to cultivating or succession phases. So called stenotopic woodland species however are in extensive orchards restricted on succession areas or border on woodlands (*M. elatus, C. coriaceus, C. nemoralis*). They indicate thereby a strong change of the carabid community on a complete abandonment.

Beside the differential species there are obviously some highly steady species (steadyness III), which colonize all studied plots in nearly the same density, whenever it is remarquable that they also reflect a specific tendency of cultivation. *H. latus* (macropteric) colonizes on less nutrient cutting meadows and pastures in a slightly higher density than on mulching meadows and abandoned meadows. Its centre of distribution in the grassland remains more likely on ologotrophic areas (TIETZE 1985, Fig. 2).

Pt. ovoideus (brachypteric), colonises 2-cutting meadows, mulching meadows und abandoned meadows more frequently.

The area specific percentages of the steadyness groups I–III are obviously not influenced by the management form of the study plots. On the species rich cutting meadows and pastures especially rare species are not found more frequent compared to low species areas as mulching meadows and abandoned meadows. But the area specific percentages of steadyness group I decrease tendentious with decreasing size and increasing altitude of the plots. For larger plots are more frequent at the bottom of the "Limburg" area, and therefore at the border of the study area, the higher percentage of rare species on this plots can be true to influences of the surrounding areas. This influence became scarcer – regarding overall influences – with increasing distance of the studied plots from the border in the centre of the "Limburg" area.

5. ZUSAMMENFASSUNG

Von April 1995 bis November 1997 wurden in den Streuobstwiesen des Naturschutzgebietes Limburg bei Weilheim/Teck (48.38 N/9.23 E) auf einer Fläche von etwa 62,7 ha (857 Flurstücke, Abb. 1) Kartierungen, Erfassungen und Messungen der Grünlandnutzung und –häufigkeit, Vegetation und Carabidenfauna durchgeführt. Dabei wurden 17 Probeflächen mit einem teilweise seit über 25 Jahren unveränderten spezifischen Management ausgewählt. Nutzungsformen waren: dreischürige Mähwiesen (3), zweischürige Mähwiesen (3), Mulchwiesen (4), Sukzessionsflächen (3), eine Pferdeweide, eine Schaf-Standweide, eine Schaf-Umtriebsweide und eine 1994 aufgelassene Schaf-Standweide.

Im Gebiet der 17 Probeflächen wurden insgesamt 68 Species registriert (Tab. 2). Auf annähernd allen Flächen wechselte in den einzelenen Jahren die relative Häufigkeit der dominanten Spezies. Dreischürige Mähwiesen besitzen häufig eine einseitige Dominanzstruktur. Innerhalb der järlichen Spektren der Aktivitätsdominanz wurden auf allen Flächen kontinuierlich Neuzugänge und Abgänge registriert.

Im Areal seltene Species (Stetigkeitsklasse I: auf 1–3 Flächen präsent) besaßen Anteile zwischen 10 % und 42 %, die entsprechenden Werte für Stetigkeitsklasse II (auf 4–6 Flächen präsent) betrugen 0 % und 67 % und für Stetigkeitsklasse III (auf 7–10 Flächen präsent) 20 und 64 % (Abb. 2, Tab. 3). Die Bewirtschaftung des Unterwuchses von Streuobstwiesen hinsichtlich der Beeinflussung der Zönosen wird diskutiert.

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